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A limited and customized follow-up seems justified after endovascular abdominal aneurysm repair in octogenarians

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Objective: The objective of this study was to determine whether long-term follow-up after endovascular aneurysm repair (EVAR) is justified in octogenarians.

Methods: Between September 1996 and October 2011, all patients, including octogenarians, treated for an abdominal aortic aneurysm (AAA) by EVAR were included in a prospective database. Patients older than 80 years and with a nonruptured infrarenal aneurysm treated electively or urgently were included in the study (study group [SG]). Patients with ruptured aneurysms and patients who died during surgery or within the first postoperative month were excluded from further analysis. The control group (CG) consisted of patients younger than 80 years, matched for gender and AAA diameter. All patients were evaluated 4 to 8 weeks after EVAR and then annually thereafter. Follow-up data were complemented by review of the computerized hospital registry and charts and by contact of the patient's general practitioner or referring hospital. Primary outcomes were stent- or aneurysm-related complications and interventions. Secondary outcomes were additional surgical complications and patient survival.

Results: A total number of 193 patients (SG, $n = 97$; CG, $n = 96$) were included for analysis. Median age was 80 years, and 88.6% were male. Median follow-up time was 33.6 months (interquartile range [IQR], 12.9-68.3). Stent- and procedure-related postoperative complications were comparable between groups (SG, 41.2%; CG, 39.6%; $P = .82$). Median time to complication was 2.3 months (IQR, 0.2-19.4) in the SG compared with 18.1 months (IQR, 6.8-50.5) in the CG. The 2-year complication-free survival rates were 58% (SG) and 60% (CG). Interventions were performed significantly less frequently in octogenarians (SG, 8.2%; CG, 19.8%; $P < .05$). Median time to intervention was 11.1 months (IQR, 2.0-31.0) in the SG compared with 54.3 months (IQR, 15.0-93.2) in the CG. The 2-year intervention-free survival rates were 90% (SG) and 92% (CG). During follow-up, 98 patients died (SG, $n = 54$; CG, $n = 44$); median time to death was 31.8 months (IQR, 13.3-66.0) in the SG compared with 44.4 months (IQR, 15.0-77.7) in the CG. One aneurysm-related death occurred in the CG. The 2- and 5-year survival rates were 71% and 32% for the SG compared with 77% and 66% for the CG ($P < .05$).

Conclusions: Because of the low incidence of secondary procedures and AAA-related deaths in octogenarians, long-term and frequent follow-up after EVAR seems questionable. An adapted and shortened follow-up seems warranted in this patient group. (*J Vasc Surg* 2014;59:1232-40.)

During the past decades, the life expectancy in the Western world has increased steadily. In The Netherlands, the number of people older than 80 years has increased from 3.2% in 2000 to 4.2% in 2013.¹ A similar growth is also observed in the United States, where the cohort of octogenarians has increased from 3.3% in 2000 to 3.6% in 2010.² Reports further indicate that the number of octogenarians will continue to rise in the coming years.³ As an abdominal aortic aneurysm (AAA) is an age-related disease, the number of octogenarians seeking treatment for an AAA

will continue to rise. Even though the life expectancy of octogenarians increases after aortic aneurysm repair, this patient population is highly susceptible to postoperative complications, especially after open repair.⁴⁻⁷ With the introduction of endovascular aneurysm repair (EVAR), octogenarians can be offered a much less invasive treatment, making EVAR the preferred treatment in this vulnerable group.⁸⁻¹³

Although EVAR is associated with much less morbidity and fewer short-term complications than in open repair, stent graft-related complications such as endoleak and stent fractures or occlusions are challenging and difficult-to-treat complications.^{13,14} According to the current literature, the intervention rate after EVAR is estimated at 10% per year, and therefore lifelong patient surveillance is currently recommended.¹⁵ With an already natural limited life expectancy (mean survival of 6.1 years), octogenarians are more likely to die of other causes than those related to the aneurysm.¹⁶ Therefore, frequent and accurate monitoring for endoleak development or stent graft migration is probably of less importance in the elderly compared with their younger counterparts. Whether watchful waiting

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is justified, as opposed to treating all endoleaks in these frail patients, is not yet known. The aim of this study was to determine the complication and intervention rates after EVAR in octogenarians compared with those in younger patients. In addition, the time between EVAR and occurrence of complications or interventions was assessed to evaluate whether a customized follow-up is applicable.

METHODS

Design of the study. Between September 1996 and October 2011, 1160 patients underwent EVAR for an infrarenal aortic aneurysm; 115 patients were 80 years or older at the time of surgery. Exclusion criteria were a ruptured aneurysm ($n = 17$) and death during surgery or within the first postoperative month ($n = 1$). The remaining 97 patients formed the study group (SG). A control group (CG, $n = 96$) was composed of patients younger than 80 years and matched for gender and AAA diameter. For one patient, no match could be found. All patients gave full informed consent before surgery after being informed about the surgery and possible complications as well as alternatives for EVAR, such as open aortic surgery or watchful waiting. Preoperative collected data included age, gender, American Society of Anesthesiologists (ASA) score, and Charlson Comorbidity Index.^{17,18} Intraoperative predictors were duration of surgery, type of anesthesia, anatomy and aneurysm configuration, type of AAA repair, and stent graft device. Postoperative predictors and outcome were hospital length of stay, intensive care unit admittance, and stent- and surgery-related complications. Surgical complications were classified according to the Clavien-Dindo Classification of Surgical Complications.^{19,20}

Procedure. All procedures were performed at our university medical center by an interdisciplinary team consisting of vascular surgeons experienced with all types of devices, an interventional radiologist, and an anesthesiologist. The preferred type of anesthesia was local anesthesia, which was applied in 74.1% of patients (SG, 82.5%; CG, 65.6%). In case of pain despite local anesthesia, adiposity, or previous groin surgery, regional (SG, 9.3%; CG, 18.8%) or general (SG, 8.2%; CG, 15.6%) anesthesia was applied. The choice for either alternative was based on the patient's and anesthesiologist's preference.

All the devices used were CE (Communauté Européenne) Mark-approved; they included different types of stent grafts from various companies, including Boston Scientific Vascular, Cook Medical, Cordis, Medtronic, Vascutek Ltd, and W. L. Gore and Associates. In general, we attended to the specific instructions for use as proposed by the manufacturing companies. Both the technique and the considerations for EVAR have been published previously.²¹

Follow-up. All patients received computed tomographic angiography between 4 and 8 weeks after EVAR to assess the position and configuration of the stent graft and to detect new or previously unnoticed endoleaks. Patients were further monitored with an annual four-view abdominal radiograph and duplex ultrasound scan. Primary outcome measures were any stent- or aneurysm-related

complication and the subsequent intervention. The endoleak types were categorized according to the classification described by White et al.²² Further attention was given to aneurysm growth; stent graft migration, kinking, thrombosis, and occlusion; any type of stent graft failure (including type III and type IV endoleak); and stent graft infections. Stent graft kinking was graded by the system as recommended by Chaikof et al. In this system, grade I signifies induced curvature, without acute angulation. Grade II indicates angulation of more than 30 degrees, and grade III refers to angulation of more than 30 degrees along with obstruction of the device (IIIa) or disconnection (IIIb).²³ Stent graft thrombosis was defined as a reduction of the lumen diameter >50% based on mural thrombus visible on duplex ultrasound examination independent of clinical signs.

Interventions were classified as endovascular leg or body extension, coiling of target vessels, endovascular relining, crossover bypass, and conversion to open repair. Secondary outcome measures were additional surgical complications and patient survival.

Statistical analysis. Categorical variables were presented as numbers or percentages. Continuous variables were presented as median and interquartile range (IQR). In cases of fewer than five events, continuous variables were expressed as mean with standard deviation because no reliable IQR could be calculated. Categorical variables were analyzed by means of the χ^2 test or Fisher exact test. Continuous variables were tested with the Student *t*-test for normal distribution and the Mann-Whitney *U* test for skewed distribution. Complication- and intervention-free survival rates were calculated by means of Kaplan-Meier analysis. Differences in survival and outcome were determined by log-rank testing. Two-tailed *P* values were used throughout, and significance was set at $P < .05$. All statistical analyses were done with the Statistical Package for the Social Sciences (SPSS 16.0.1; SPSS, Chicago, Ill).

RESULTS

Patients and procedures

The majority of patients were treated for an asymptomatic aneurysm (SG, 89.7%; CG, 96.9%). The remainder (SG, 10.3%; CG, 3.1%) were symptomatic aneurysms, which required more urgent treatment. ASA classification was determined by the anesthesiologist. All patients were assigned to ASA grade II (SG, 53.6%; CG, 50%) and grade III (SG, 46.4%; CG, 50%). Patient characteristics are summarized in Table I. Twelve patients experienced intraoperative complications (SG, $n = 4$; CG, $n = 8$). These complications are stated in Table II.

Stent graft-related complications

Seventy-eight patients (40.4%; SG, 41.2%; CG, 39.6%; $P = .82$) developed 145 (SG, $n = 63$; CG, $n = 82$) stent-related complications after EVAR after a median of 12.9 months (IQR, 2.9-38.5). Thirty-eight patients had one complication (SG, $n = 23$; CG, $n = 15$), 22 patients had two complications (SG, $n = 12$; CG, $n = 10$), and 18

Table I. Baseline characteristics

Parameter	Total (N = 193)	Patients ≥80 years (n = 97)	Patients <80 years (n = 96)	P value
Age, years	80 (72-82)	82 (81-84)	72 (65-76)	
Gender, male	171 (88.6)	86 (88.7)	85 (88.5)	
ASA ^a	2 (2-3)	2 (2-3)	2 (2-3)	.83
Comorbidity (CCI) ^b	6 (5-7)	6 (5-7)	5 (4-6)	<.05
AAA diameter, mm	60 (56-68)	60 (57-68)	60 (56-68)	
Urgency (elective)	180 (93.3)	87 (89.7)	93 (96.9)	<.05
Duration of surgery, minutes	130 (110-159)	141 (113-165)	120 (100-140)	<.05
ICU admittance, No. of patients	3 (1.6)	1 (1.0)	2 (2.1)	.62
ICU admittance, days	2	2	2	NA
Hospital length of stay, days	5 (4-6)	5 (4-6)	5 (4-7)	.82

AAA, Abdominal aortic aneurysm; ASA, American Society of Anesthesiologists; CCI, Charlson Comorbidity Index; ICU, intensive care unit; IQR, interquartile range; NA, not applicable.

Categorical variables are presented as number (%) and continuous variables are presented as median and IQR. *P* values < .05 were considered significant.

^aASA score: five-category physical classification system for assessing the fitness of patients before surgery.

^bCCI: predicts the 1-year mortality by scoring of the patients' comorbidities.

Table II. Intraoperative complications

Type of complication	Total, No. (%)	Patients ≥80 years, No. (%)	Patients <80 years, No. (%)	P value
Iliofemoral crossover bypass necessary	1 (1.0)	1 (1.0)	0 (0)	NA
Internal iliac artery occlusion	9 (4.7)	2 (2.1)	7 (7.3)	.10
Conduit necessary for access	1 (1.0)	1 (1.0)	0 (0)	NA
Bridging stent graft necessary	1 (0.5)	0 (0)	1 (1.0)	NA
Total	12 (6.2)	4 (4.1)	8 (8.3)	.23

NA, Not applicable.

P values < .05 were considered significant.

patients (SG, *n* = 5; CG, *n* = 13) had three or more stent-related complications during follow-up. There were significantly more patients who had interventions in the CG compared with the SG (SG, 8.2%; CG, 19.8%; *P* = .02).

In the SG, median time to complication was 2.3 months (IQR, 0.2-19.4). Forty-one complications (41 of 63; 65.1%) occurred within the first 12 months after the initial EVAR. The accompanying 2-year complication-free survival was 58% (Fig 1). A total of nine interventions were necessary in eight patients (8.2%). Median time to intervention was 11.1 months (IQR, 2.0-31.1) (Table III). Six interventions (6 of 9; 66.7%) were performed within the first year after EVAR. The 2-year intervention-free survival was 92% (Fig 2). EVAR-related complications and secondary interventions in the SG were independent of sex (*P* = .11 and *P* = .91, respectively), urgency (*P* = .21 and *P* = .83, respectively), ASA score (*P* = .82 and *P* = .83, respectively), comorbidity (*P* = .07 and *P* = .58, respectively), or AAA diameter at the time of EVAR (*P* = .55 and *P* = .25, respectively).

In the CG, median time to complication was 18.1 months (IQR, 6.8-50.5). Nineteen patients (19.8%) had 27 interventions after a median of 54.3 months (IQR, 15.0-93.2) (Table IV).

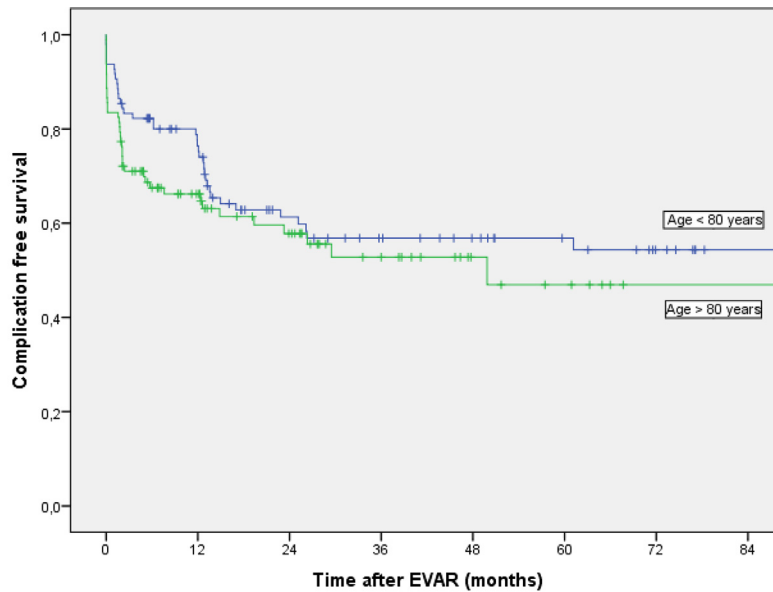
In the following paragraphs, the individual complications are addressed.

Endoleak. A total of 36 endoleaks, including types Ia, Ib, II, and III, occurred in 34 patients (35.1%) in the SG compared with 36 endoleaks in 29 patients (30.2%)

in the CG. Intervention was performed in 16.7% of endoleaks in the SG (6 of 36) compared with 44.4% in the CG (16 of 36).

Type Ia endoleak occurred in 11 patients (5.7%), with no significant difference between the SG (5.2%) and the CG (6.5%). In three patients (3 of 11, 27.3%), successful placement of a proximal extension was performed (SG, 2 of 5 [40%]; CG, 1 of 6 [16.7%]). In seven patients (3.6%), type Ib endoleaks were detected (SG, 1.0%; CG, 6.3%). All type Ib endoleaks in the CG were corrected. The patient in the SG declined further follow-up.

The most common complication was a type II endoleak that occurred in 45 patients (23.3%), with no significant difference between the SG (27.8%) and the CG (18.8%; *P* = .18). Two patients in the SG (2 of 27; 7.4%) underwent coiling because of aneurysm growth. In one patient, a previously unnoticed type III endoleak was discovered, for which an endovascular relining was necessary. One patient had unsuccessful coiling, and after 3 months, the endoleak spontaneously disappeared. The remaining 25 patients (25 of 27; 92.6%) had a "wait-and-see" approach. In 13 patients (13 of 25; 52.0%), the endoleak disappeared over time; and in 12 patients (12 of 25; 48.0%), an intervention was waived because of frailty of the patient or limited or absent aneurysm growth. No aneurysm-related deaths occurred in the SG during follow-up. In the CG, an intervention was necessary in five patients who presented with type II endoleak (5 of 18; 17.8%).



Time, months	0	12	24	36	48	60	72	84
≥80 years, No.	97	45	31	17	9	5	1	1
Standard error	0%	5%	5.5%	6%	7%	7%	7.7%	7.7%
<80 years, No.	96	63	40	32	28	23	17	10
Standard error	0%	4.5%	5.4%	5.5%	5.8%	5.8%	5.8%	5.8%

Fig 1. Probability of complication-free survival after endovascular aneurysm repair (EVAR): Comparison of patients ≥ 80 years of age and patients < 80 years (according to the Kaplan-Meier method). There is no statistical significance between the two groups (log-rank, $P = .27$).

Table III. Endovascular aneurysm repair (EVAR)-related complications in patients ≥ 80 years

Type of complication	No. (%)	Time since EVAR, months	Intervention, No. (%)	Time since EVAR, months	Disappeared, No. (%)
Type Ia endoleak	5 (5.2)	0.03 (0.01-1.1) ^a	2 (40)	2.0 \pm 2.7 ^b	3 (60)
Type Ib endoleak	1 (1.0)	29.5	0 (0)		0 (0)
Type II endoleak	27 (27.8)	1.9 (0.1-2.4) ^a	2 (7.4)	9.5 \pm 2.3 ^b	13 (48.1)
Type III	3 (3.1)	28.1 \pm 19.8 ^b	2 (66.7)	31.2 \pm 28.4 ^b	0 (0)
Migration	6 (6.2)	15.9 (5.5-26.4) ^a	2 (33.3)	31.1 \pm 10.0 ^b	0 (0)
Kinking	8 (8.2)	12.3 (0.5-36.6) ^a	0 (0)		0 (0)
Thrombosis	2 (2.1)	6.3 \pm 8.9 ^b	1 (50)	0.03	0 (0)
Growth	11 (11.3)	12.4 (4.9-31.1) ^a			
Total	63 (40 patients; 41.2%)	2.3 (0.2-19.4) ^a	9 (8 patients; 8.2%)	11.1 (2.0-31.1) ^a	16 (25.4)

^aPresented as median and interquartile ranges.

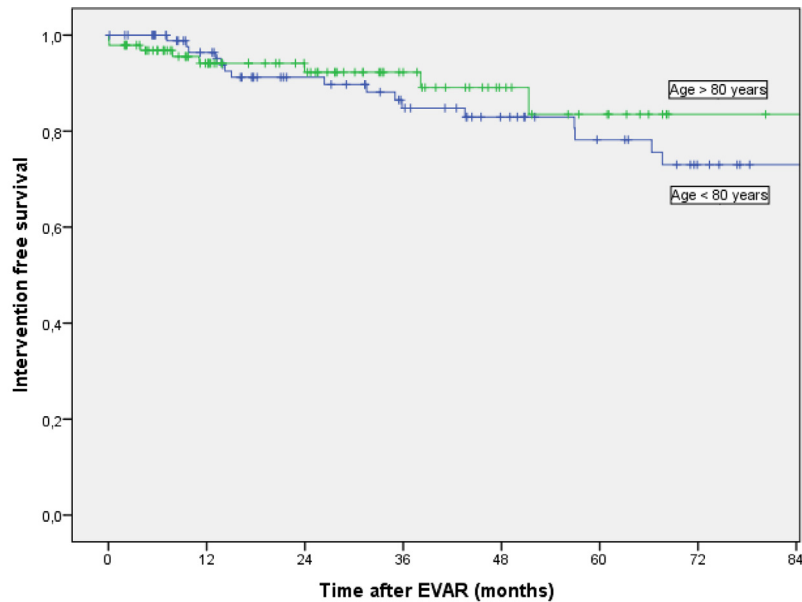
^bPresented as mean \pm standard deviation.

Nine patients (4.7%) presented with stent graft failure consisting of a type III endoleak, with no significant difference between the groups (SG, 3.1%; CG, 6.3%; $P = .33$). In the SG, two patients (2 of 3; 66.7%) had an intervention consisting of endovascular relining and leg extension, respectively (CG, 4 of 6; 66.7%). One patient did not receive an intervention because of lack of aneurysm growth. There were no type IV endoleaks identified.

Stent graft migration, kinking, and thrombosis or occlusion. Stent graft migration occurred six times in five patients (5.2%) in the SG. Two patients (2 of 5; 33.3%)

needed an intervention consisting of a unilateral leg extension and conversion to open repair with an aortic bifurcation graft, respectively. In the remainder, no interventions were performed, as the migration was not considered severe enough. In the CG, migration of the graft was detected in six patients (6.3%), and two patients (2 of 6; 33.3%) needed an intervention.

Stent graft kinking was seen in 25 patients (13%), with no statistical difference between groups (SG, 8.2%; CG, 17.7%; $P = .05$). Two interventions were performed in the CG (2 of 17; 11.8%). In the SG, none of the cases



Time, months	0	12	24	36	48	60	72	84
≥80 years, No.	97	68	49	30	18	11	4	2
Standard error	0%	2.6%	3.1%	4.3%	6.8%	6.8%	6.8%	6.8%
<80 years, No.	96	77	60	50	40	32	24	18
Standard error	0%	2%	3.5%	4.3%	4.6%	5.4%	6.2%	7%

Fig 2. Probability of intervention-free survival after endovascular aneurysm repair (EVAR): Comparison of patients ≥ 80 years of age and patients < 80 years (according to the Kaplan-Meier method). There is no statistical significance between the two groups (log-rank, $P = .48$).

Table IV. Endovascular aneurysm repair (EVAR)-related complications in patients < 80 years

Type of complication	No. (%)	Time since EVAR, months	Intervention, No. (%)	Time since EVAR, months	Disappeared, No. (%)
Type Ia endoleak	6 (6.3)	0.7 (0.01-81.1) ^a	1 (16.7)	9.5	1 (16.7)
Type Ib endoleak	6 (6.3)	34.6 (21.1-73) ^a	6 (100)	53.0 \pm 40.4 ^b	0 (0)
Type II endoleak	18 (18.8)	4.3 (1.6-29.7) ^a	5 (27.8)	67.7 \pm 34.2 ^b	5 (27.8)
Type III	6 (6.3)	84.3 \pm 64.7 ^b	4 (66.7)	112.5 \pm 68.2 ^b	0 (0)
Migration	6 (6.3)	29.3 (13.1-38.6) ^a	2 (33.3)	39.5 \pm 11.3 ^b	0 (0)
Kinking	17 (17.5)	13 (11.9-24) ^a	2 (11.8)	39.3 \pm 6.0 ^b	0 (0)
Thrombosis	6 (6.3)	32.7 (2.9-101.8) ^a	6 (100)	51.5 \pm 50.7 ^b	0 (0)
Growth	16 (16.7)	37.9 (13.3-55.1) ^a			
Infection	1 (1.0)	67.9	1 (100)	67.9	0 (0)
Total	82 (38 patients; 39.6%)	18.1 (6.8-50.5) ^a	27 (19 patients; 19.8%)	54.3 (15.0-93.2) ^a	6 (7.3)

^aPresented as median and interquartile ranges.

^bPresented as mean \pm standard deviation.

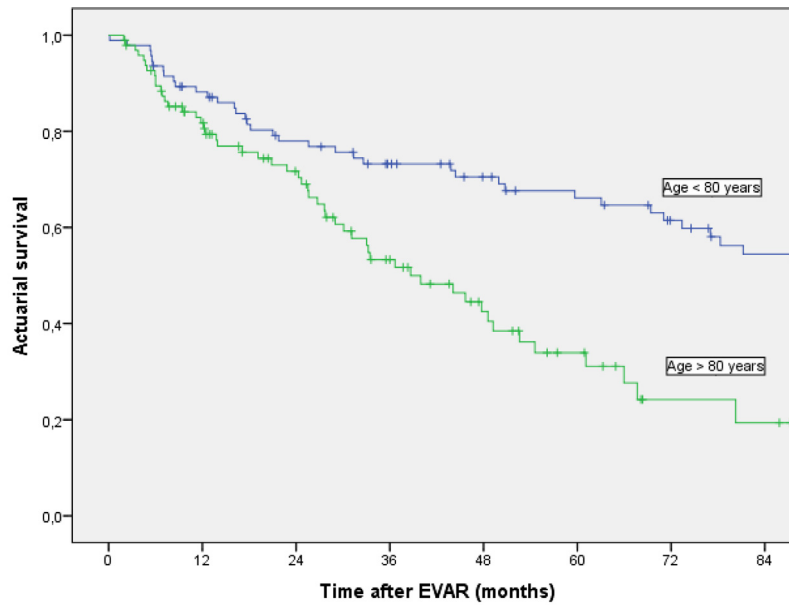
was classified as a grade III deformation. For all patients, a watchful policy was implemented, after which no further complications occurred.

Stent graft thrombosis or occlusion was seen in eight patients (4.1%), with no significant difference between the SG (2.1%) and the CG (6.3%). In the SG, occlusion of the graft was observed in one patient on the first postoperative day, after which surgical thrombectomy and endovascular relining were performed. In the second patient, an asymptomatic 50% stenosis was visible on duplex

scanning, which was later diagnosed as thrombus on a computed tomography scan.

In the CG, all patients had secondary interventions.

Aneurysm growth. In the SG, there was persistent aneurysm growth after EVAR in 11 patients (11.3%), mainly due to type II endoleaks (7 of 11; 63.6%). Other causes of aneurysm growth after EVAR were type Ia (1 of 11; 9.1%), type Ib (1 of 11; 9.1%), and type III endoleak (1 of 11; 9.1%). In one patient, no apparent cause of the aneurysm growth could be determined. Two type II



Time, months	0	12	24	36	48	60	72	84
≥80 years, No.	97	71	53	33	21	12	5	3
Standard error	0%	4%	4.8%	5.8%	6%	6.3%	6.5%	6.8%
<80 years, No.	96	79	66	57	50	44	37	30
Standard error	0%	3.5%	4.4%	4.7%	4.9%	5.2%	5.5%	5.9%

Fig 3. Probability of survival after endovascular aneurysm repair (EVAR): Comparison of patients ≥80 years of age and patients <80 years (according to the Kaplan-Meier method). There is statistical significance between the two groups (log-rank, $P < .05$).

endoleaks were corrected by coiling. The type Ia endoleak was corrected by placement of an extension, and the type III endoleak was corrected by endovascular relining. In six patients, a wait-and-see policy seemed permissible. In one patient, the cause of aneurysm growth was unknown. However, after initial growth of the aneurysm, the diameter remained stable during follow-up. In all other patients, endoleak type II was the underlying cause of aneurysm growth. In one patient, the size of the aneurysm did not increase any further during follow-up after the initial growth was adjusted. In the remaining three patients, advanced age and comorbidity were the main reasons to suppose that the benefits of an intervention would not outweigh the negative side effects. Along with the opinion of the surgeon, the wish of the patient played a major role in the decision-making in these cases. One patient refused further treatment.

Aneurysm growth was detected in 16 patients (16.7%) in the CG.

Infection. Infection of the stent graft did not occur in the SG during follow-up. In the CG, one patient (1.0%) presented with infection, and this patient had immediate surgery.

Additional surgical complications

Thirty-nine patients (SG, $n = 24$; CG, $n = 15$; $P = .1$) experienced surgical complications as classified by the Clavien-Dindo system.^{19,20} In 23 patients (SG, $n = 10$;

Table V. Causes of death

	Total, No. (%)	Age ≥80 years, No. (%)	Age <80 years, No. (%)	P value
Aneurysm-related	1 (.5)	0 (0)	1 (1.0)	NA
Neurologic	3 (1.6)	1 (1.0)	2 (2.1)	.62
Cardiac	11 (5.7)	5 (5.2)	6 (6.3)	.74
Pulmonary	12 (6.2)	10 (10.3)	2 (2.1)	<.05
Malignant disease	20 (10.4)	6 (6.2)	14 (14.6)	.06
Multiorgan failure	4 (4.1)	0 (0)	4 (4.2)	NA
Other	15 (7.8)	12 (12.4)	3 (3.1)	<.05
Unknown	32 (16.6)	20 (20.1)	12 (12.5)	.13
Total	98 (50.8)	54 (55.7)	44 (45.8)	.22

NA, Not applicable.

P values < .05 were considered significant.

CG, $n = 13$), the complication was specified as a grade I complication, defined by any deviation from the normal postoperative course without the need for pharmacologic treatment. In 15 patients (SG, $n = 13$; CG, $n = 2$), pharmacologic treatment was necessary (grade II). One patient in the SG required a surgical intervention (grade III).

Patient survival

Ninety-eight patients (SG, $n = 54$; CG, $n = 44$; $P = .2$) died during follow-up. The median survival was

31.8 months (IQR, 13.3-66.0) in the SG compared with 44.4 months (IQR, 15.0-77.7) in the CG. The 2- and 5-year survival rates were 71% and 32% (SG) and 77% and 66% (CG) (Fig 3). The estimated risk for death was significantly higher in the SG compared with the CG (log-rank, $P < .05$). One patient in the CG died of a ruptured aneurysm. Sixty-five patients (65 of 98; 66.3%) died of unrelated causes; in 32 patients (32 of 98; 32.7%), the cause of death could not be ascertained despite close follow-up (Table V).

DISCUSSION

This study shows that although stent-related complications after EVAR certainly occur in the elderly, 65.1% occur within the first year after EVAR. Also, only 8.2% of octogenarians will undergo an intervention without affecting the number of AAA-related deaths. Therefore, one may wonder whether long-term and frequent follow-up after EVAR is necessary. Previous studies have found that the higher rates of endoleak in octogenarians do not increase the risk of interventions or ruptures.^{24,25} Because an intervention was actually indispensable in only a minority of patients in our SG, the majority of registered complications during follow-up can be considered of minor importance. This in turn could mean that 90% of octogenarians currently are receiving follow-up for no apparent reason. Although more research is clearly necessary for a definitive conclusion to be reached, octogenarians should be approached differently from their younger counterparts. Impaired mobility, multiple pathologic processes, and medicine use make regular follow-up a mental and physical strain in octogenarians. In dealing with frail elderly patients, the risks must always be balanced against the benefits of surgery. Even though good results after EVAR have been reported, one can raise questions on costs and benefit. With the current climate of cost containment and limited reimbursement for health care delivery, a critical analysis of the costs vs relative benefits remains important, certainly in treating octogenarians, for whom median survival remains limited by the natural life expectancy. Current literature clearly shows that EVAR is appreciably more expensive than open repair. Also, the decreased length of stay in the intensive care unit and hospital does not compensate for the cost of EVAR. With the proposed reductions in reimbursement, the ability to cover the cost may be threatened. Because long-term surveillance is considered mandatory after EVAR, the follow-up costs will further increase the cost disparity between EVAR and open repair.

Our results with regard to EVAR-related complications are consistent with the current literature.^{15,24} We found a significant difference when it comes to intervention rates between octogenarians and patients younger than 80 years (8.2% vs 19.8%; $P < .05$). Moreover, younger patients underwent three times more interventions compared with octogenarians (CG, $n = 27$; SG, 9). In octogenarians, watchful waiting was considered sufficient on the basis of

advanced age. This seems to be a justifiable choice when the low AAA-related death rate is taken into account.

In recent years, there has been a huge paradigm shift with respect to the treatment of octogenarians, and AAA repair has proved to be a safe procedure in this vulnerable group.²⁵⁻²⁷ The shorter hospitalization period and quick return to former level of functioning are of vital importance for octogenarians, making EVAR the treatment of choice. In terms of quality of life, it has been established that for the most part, this is preserved in octogenarians after EVAR.¹⁴ Follow-up, with hospital visits preceding burdensome and sometimes harmful tests, may be experienced as stressful by older patients. In our series, this has even led to a significantly higher rate of patients lost to follow-up in the SG compared with the CG ($P < .05$). When asked, the majority of patients indicated that the outpatient visits were becoming burdensome. A reduction in the amount of outpatient clinic visits could increase quality of life and reduce costs. The diagnostic costs after EVAR account for 8.2% of the total hospital costs (\$1760 of \$21,250), compared with 5.7% after open repair (\$698 of \$12,342).²⁸ This difference increases with longer follow-up.²⁹

Of the 54 patients in the SG (55.7%) who died during follow-up, no deaths were aneurysm-related. These figures correspond with the literature and contribute to the growing doubt as to whether a long-term follow-up is really meaningful or just common practice.^{13,30,31}

The majority of complications in our SG (42.9%) were type II endoleaks, and 48.1% disappeared without an intervention. Although this percentage is less than reported in the literature, a significant part vanishes over time.³² A possible explanation for the lower rate in our series is that we considered type II endoleaks significant when still visible by computed tomographic angiography 8 weeks postoperatively. By exclusion of small endoleaks visible at the completion angiogram, a higher percentage of persistent endoleaks remain. Conservative treatment of type II endoleaks is considered safe in the absence of aneurysm growth.³³

Although the incidence of complications after EVAR has significantly decreased in recent years, it is expected that with the advent of new technologies and further growth of complex EVAR expertise, complication rates will be even lower.^{12,34} This is further supported by the fact that 46.9% of patients in our study who had surgery between 1996 and 2005 had one or more complications compared with only 33.7% treated between 2006 and 2011 ($P = .06$). Furthermore, only 4.2% of patients who were treated between 2006 and 2011 required an intervention compared with 23.5% of patients who were treated between 1996 and 2005 ($P < .05$).

The 2- and 5-year actuarial survival rates in our SG are 71% and 32% (CG, 77% and 66%). These results are fairly similar to the literature with reported 2-year survival rates of 68%, although outliers with an 8-year survival of 64% are also reported.^{25,35}

As our study has a great time range, many different stent grafts have been used in the study population.

Recently, the effect of stent graft model on aneurysm shrinkage has been described. The authors concluded that newer-generation devices have a greater effect on aneurysm shrinkage lasting up to 10 years.³⁶ This would also mean that a shorter follow-up period is even more justifiable with newer stent grafts.

This study has some limitations that need to be addressed. Although an intention-to-treat principle was applied, we excluded one patient who died of cardiac arrest within the first month after surgery. We thought that this was a legitimate choice in a study focusing on postoperative complications. In addition, we believe that this one patient would not have altered the results. We adopted a strategy to treat all patients unless they had a very poor performance score (Karnofsky performance score ≤ 40).⁴ As such, 95% of the patients received full treatment regardless of age, making it unlikely that a selection bias based on urgency has occurred. Ruptured aneurysms were excluded as the risk of complications is considerably higher in these patients compared with patients undergoing elective operation.³⁷ In terms of safety, however, it was shown recently that octogenarians with a ruptured AAA can be treated with a more than acceptable outcome.⁴ In this study, 12.4% of patients had an AAA diameter of <55 mm. Although a diameter of 55 mm is internationally accepted as the threshold for intervention, it is justified to perform surgery in patients with rapid aneurysm growth (>5 mm in the last 6 months) ($n = 7$), symptoms ($n = 1$), saccular aneurysms ($n = 3$), and familial predisposal for aneurysms ($n = 2$).³⁸ Our CG consisted of a matched group of patients younger than 80 years at the time of the procedure. Unfortunately, for one patient in the SG, no sufficient match could be found. All data from a prospectively held database were retrospectively analyzed. Also, a large part of the study population consisted of a historical cohort, and as a result detailed anatomic characteristics are lacking. Hence, it was not possible to reliably determine which patients were treated outside the instructions for use.

In 20 patients in the SG, the cause of death could not be reliably ascertained. As a result, a number of patients could still have died of an aneurysm-related cause and gone unnoticed. A relative underestimation of the aneurysm-related death rate therefore cannot be ruled out. However, in these patients, the median time interval between the last follow-up visit and death was 4.4 months (IQR, 3.1-15.8). Also in 80% of patients, there were no aneurysm- or stent graft-related complications during the last follow-up. Therefore, the probability of aneurysm-related deaths in this group is very small.

CONCLUSIONS

In this study, the incidence of interventions and AAA-related death was lower in octogenarians than in younger patients. Therefore, an adapted and shortened follow-up seems warranted in octogenarians after EVAR. A shortened follow-up will most likely have no effect on patient survival but may lower the total amount of EVAR costs and increase quality of life. In patients with any type of complication,

additional follow-up is recommended. More research is needed to confirm the results of this study. Ideally, after greater insights are obtained into stent-related complications, tailor-made follow-up schemes regarding duration and intensity could be developed.

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AUTHOR CONTRIBUTIONS

Conception and design: LV, RP, CZ

Analysis and interpretation: LV, RP, IT, CZ

Data collection: LV, RP

Writing the article: LV, RP

Critical revision of the article: LV, RP, IT, JvdD, CZ

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